



Examining the *Acacia boormanii* complex (Fabaceae: Mimosoideae); recognition of a new subspecies

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Introduction

The iconic genus *Acacia* Mill. (Leguminosae: Mimosoideae) is the largest angiosperm genus in Australia, consisting of over 1000 species (Miller et al. 2011, Maslin 2015). *Acacia boormanii* Maiden (syn. *A. hunteriana* N.A.Wakef.) was described as a species of scattered and restricted occurrence in south-eastern Australia (Maiden 1916). As currently understood, its natural range extends from south of Thredbo Village, New South Wales (NSW), to near Buchan, Victoria, mostly south of the Great Dividing Range, with isolated occurrences near Cooma, NSW, and Myrtleford, Victoria (Maslin 2001). It is common in cultivation and has become naturalised in a few areas outside its natural range (e.g. http://avh.ala.org.au/occurrences/search?taxa=acacia+boormanii#tab_mapView). While not considered at risk, it is regarded as 'rare' in Victoria (DEPI 2014). It is a bushy, slender shrub or (rarely) tree to 4.5 m high, readily coppicing (WorldWideWattle ver. 2. Published on the Internet at: www.worldwidewattle.com [1 Jan 2018]). It is phyllodinous, with a single main nerve in each phyllode, and has globular capitula in racemose inflorescences. These characters place the species in section Phyllodineae (Maslin 2001); however, more recent phylogenetic research has found section Phyllodineae to be polyphyletic, and from its possession of a range of features, *A. boormanii* is most likely a member of a diverse assemblage of taxa informally called the 'p.u.b. clade', and within that, the

Abstract

A morphometric analysis of specimens determined as *Acacia boormanii* Maiden and *A. infecunda* Molyneux & Forrester supported a distinctive population centred on Mt Typo in north-eastern Victoria, which is described here as *A. boormanii* subsp. *gibba* K.J.Tucker subsp. nov. The characters that best separate the new subspecies are the phyllode width, the indentation of the phyllode margins at the gland, and the shape of the phyllode apex. Neither *Acacia infecunda* nor an unusual population of *A. boormanii* from Gapsted in north-east Victoria could be confidently distinguished from *A. boormanii*. *Acacia boormanii* (in the broader sense) is considered rare in Victoria, but is not considered threatened.

Keywords: *Acacia infecunda*, Mt Typo variant, Gapsted variant, morphology, morphometric analysis

Botrycephalae subclade in the classification of Murphy et al. (2010).

Herbarium specimens in the National Herbarium of Victoria (MEL) identified as *A. boormanii* from on and near Mt Typo (herein referred to as *A.* 'Typo') and Gapsted (herein *A.* 'Gapsted') in north-eastern Victoria, had previously been noted to differ from typical *A. boormanii* (Maslin 2001). Phyllodes of *A.* 'Typo' are broader than typical *A. boormanii* while unpublished chemical data suggests *A.* 'Gapsted' differs from typical *A. boormanii* and potentially from *A.* 'Typo' (Maslin 2001). A morphometric analysis was undertaken to investigate the morphological variation within the *A. boormanii* complex, including specimens of *A.* 'Typo' and *A.* 'Gapsted'.

Acacia infecunda Molyneux & Forrester was segregated from *A. boormanii* based on its smaller phyllodes and capitula, its apparent sterility, and its root-suckering habit (Molyneux and Forrester 2008). *Acacia infecunda* is known from a single population near Wulgulmerang in eastern Victoria, isolated from populations of *A. boormanii* but within the same biogeographic region of that species. Because of the presumed close relationship between *A. infecunda* and *A. boormanii* (Molyneux and Forrester 2008) it was included in the morphometric analysis.

Specimens examined in this study were sampled from across the geographical range of *A. boormanii*, including the Mt Typo and Gapsted variants (Figure 1). The aims of this study were to determine:

1. if either or both of the *A. boormanii* variants at Mt Typo and Gapsted are sufficiently distinct from *A. boormanii* to be recognised as new taxa;
2. if *A. infecunda* is sufficiently distinct to be maintained at species rank.

Methods

Sampling regime

Specimens from across the geographic range of *Acacia boormanii* and *A. infecunda*, housed in the National Herbarium of Victoria (MEL), were examined in this study. Forty-seven pre-existing *A. boormanii* specimens, of which 32 were flowering (including a probable isotype: MEL 270793), were examined in the morphometric analysis. Both of the *A. infecunda* specimens at MEL were also analysed. Herbarium material was supplemented in the analysis with fresh collections representing the range of variation within populations of typical *A. boormanii*, as well as the *A.* 'Typo' and *A.* 'Gapsted' variants, bringing the total number of specimens assessed to 55. The supplementary specimens have been lodged at MEL.

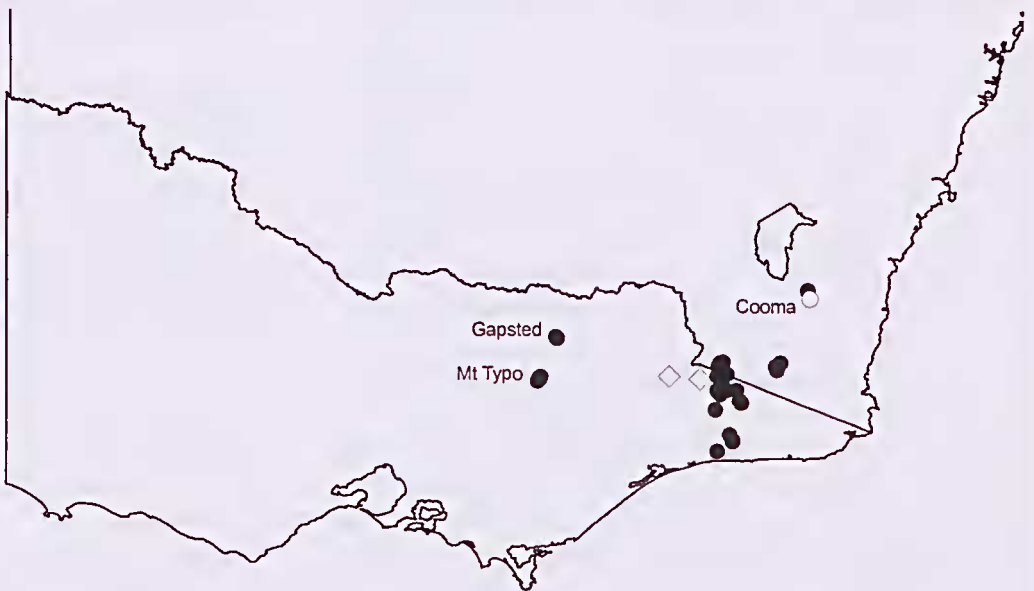


Figure 1. Map showing locations of the specimens used in the current study; ● *Acacia boormanii* (including variants from Mt Typo and Gapsted areas), ○ *A. boormanii* type, ◇ *A. infecunda*.

Morphometric characters

Floral and vegetative characters were measured including those that have been employed to distinguish *A. boormanii* from similar species in keys and *Flora* accounts and those that have been suggested to distinguish *A. infecunda* and the Typo and Gapsted variants (Maslin 2001, Molyneux & Forrester 2008) (Table 1). For each specimen three phyllodes, inflorescences and capitula were scored and the means used for the analysis. To ensure that floral characters such as raceme length, capitulum diameter and peduncle length were comparable, inflorescence characters were not measured if the specimen was not at full anthesis. To enable comparison of vegetative structures at similar stages of development, phyllode characteristics were scored two or three nodes below the terminal inflorescence or three nodes below the distal mature phyllode on non-flowering specimens. Seed and pod characters were also measured, but there were too few fruiting specimens of *A. 'Typo'* or *A. 'Gapsted'* for statistical significance and there were

no obvious differences in these features to suggest that they might be discriminatory. *Acacia infecunda* is not known to produce fruit (Molyneux and Forrester 2008).

Phenetic analyses

Morphological data were analysed phenetically using the computer package PATN (Belbin 2004). Floral and phyllode characters were analysed separately to eliminate distortion of the analysis through missing floral characters. The full dataset was range-standardised prior to applying the Gower metric to create an association matrix. An ordination was generated in three dimensions for each of the floral and phyllode characters, with 20 random starts and 100 iterations, using semi-strong hybrid multidimensional scaling. Dendrograms (one for each of the floral and vegetative datasets) were generated using the flexible unweighted pair-group method of arithmetic averages (UPGMA) classification strategy. Principal coordinate correlation (PCC) was used to evaluate the characters that strongly contributed to the observed ordination patterns.

Table 1. Characters measured for phenetic analysis and their variable types; Quantitative (Qn.), Qualitative (Ql.). Units are given in brackets where appropriate and the abbreviations used in the ordinations provided.

Character	Variable type	Abbreviation
Phyllode characters		
Phyllode apex shape (rounded or acute), ignoring mucro	Ql.	A
Density of phyllodes (phyllodes per cm)	Qn.	D
Distance from end of pulvinus to gland (mm)	Qn.	G
Hairs at base of phyllode (presence/absence)	Ql.	H
Indentation of phyllode margin where gland is positioned (presence/absence)	Ql.	I
Phyllode length (end of pulvinus to end of mucro) (mm)	Qn.	Ph.L
Phyllode width at widest section (mm)	Qn.	Ph.W
Pulvinus diameter (mm)	Qn.	Pu.D
Pulvinus length (mm)	Qn.	Pu.L
Wax on stem close to young developed phyllodes (presence/absence)	Ql.	W
Floral characters		
Phyllode angle immediately subtending inflorescence (<45°, 45–90°, 90–135°, >135°)	Ql.	A
Number of capitula per raceme	Qn.	C
Capitula diameter at anthesis (mm)	Qn.	CD
Number of flowers in each capitula (measured in mature buds)	Qn.	FN
Peduncle length (mm)	Qn.	P
Length of raceme rachis, excluding ultimate peduncle (mm)	Qn.	R

Results

The dendrogram based on phyllode characters, truncated at the two-group level (Figure 2) showed a cluster of *Acacia* 'Typo' specimens (Group 2) separating from the *A. boormanii*, *A. 'Gapsted'* and *A. infecunda* specimens (Group 1). There were also two *A. 'Typo'* specimens within Group 1. The grouping of the dendrogram based on phyllode characters was closely reflected in the ordination (Figure 3), with a stress value of 0.130. This moderate stress value indicates that the ordination is a reasonable representation of the similarity in the dataset (Clarke 1993). The PCC shows phyllode width, indentation of the phyllode margin, pulvinus diameter and shape of phyllode apices to account for the variation that separates *A. 'Typo'* from other specimens (Figure 3).

The dendrogram based on floral characters, also truncated at the two-group level, did not reveal *A. 'Typo'* specimens as a group separate from other specimens. The first group contained *A. 'Typo'* intermixed with *A. boormanii*, *A. 'Gapsted'*, and *A. infecunda*, while the other group contained only *A. boormanii* specimens (figure not shown). The ordination based on floral characters had a stress value of 0.121, and did not show a strong pattern of separation between *A. 'Typo'* and other specimens (Figure 4). The relatively low stress value here also indicates that the ordination is a good representation of the data.

Discussion

The separation of specimens of *Acacia* 'Typo' from the typical form of *A. boormanii* in both ordinations and agglomerative hierarchical clustering of vegetative morphometric data indicated that *A. 'Typo'* is distinguishable from *A. boormanii*, based on a number of traits. On this basis, and previous assertions (e.g. Maslin 2001), we consider that *A. 'Typo'* is worthy of formal taxonomic recognition. Similar to Othman et al. (2013), who studied the *Correa lawrenceana* complex, we observed incomplete separation of *A. 'Typo'*, from *A. boormanii* in the ordination analyses, and consequently we assign *A. 'Typo'* the rank of subspecies (see below). The delineation between species and subspecies can be unclear due to inconsistency in the application of the concepts and lack of objective criteria

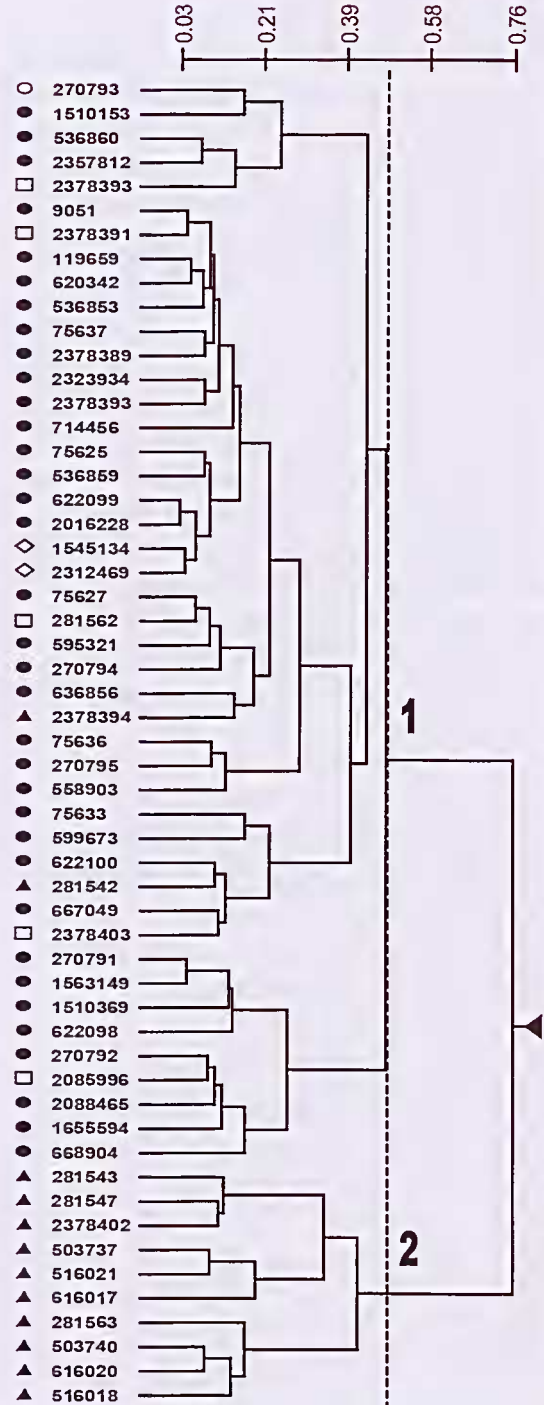
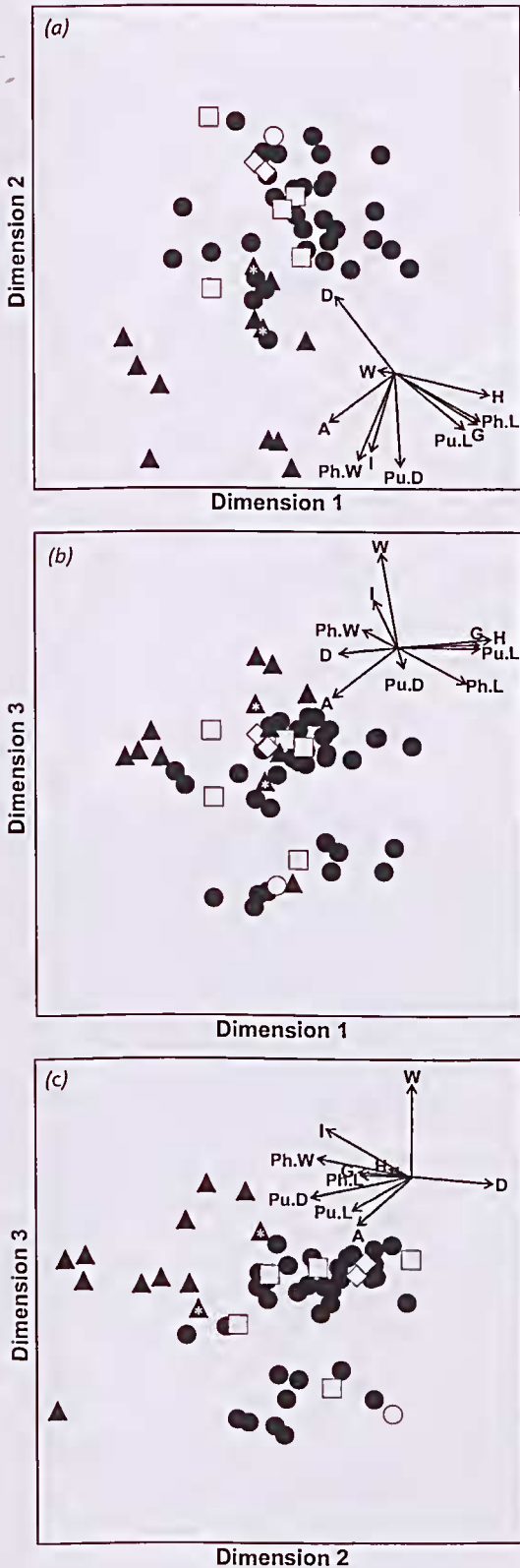


Figure 2. An agglomerative, hierarchical classification (Gower metric) of 55 specimens scored for ten phyllode characters. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A. 'Gapsted'*; ▲ *A. 'Typo'*; ▣ *A. infecunda*. Group 1 is indicated by '1' and Group 2 is indicated by '2'. Each MEL specimen is labelled with its voucher number.



LEFT: Figure 3. Three-dimensional ordination of 55 individuals based on phyllode characters for dimensions 1, 2 and 3, stress = 0, 130: **3a.** Dimensions 1 vs 2; **3b.** 1 vs 3; **3c.** 2 vs 3. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A. 'Gapsted'*; ▲ *A. 'Typo'*; ☒ *A. infecunda*. The two outlying specimens of *A. 'Typo'* (MEL2378394 and MEL281542) from Figure 1 are asterisked. The vector loadings based on principal co-ordinate correlation of phyllode characters for axes are shown. Abbreviation of character names are as follows; pulvinus length (Pu.L), pulvinus diameter (Pu.D), phyllode length (Ph.L), phyllode width (Ph.W), position of the gland (G), presence/absence of hairs (H), presence absence of wax (W), phyllode apices shape (A), indentation of phyllode margin (I), and phyllode density (D).

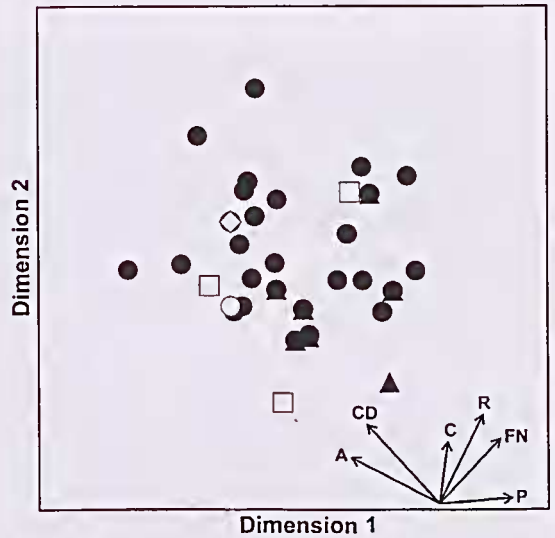


Figure 4. Three-dimensional ordination of 32 individuals based on floral characters axes 1 v. 2. ● *A. boormanii*; ○ *A. boormanii* isotype; □ *A. 'Gapsted'*; ▲ *A. 'Typo'*; ☒ *A. infecunda*. Principal coordinate correlation of floral characters. Abbreviation of floral characters are as follows; phyllode angle subtending inflorescences (A), rachis length of raceme (R), number of capitula per inflorescence (C), peduncle length (P), capitulum diameter (CD), and number of flowers per capitulum (FN).

for classification (Braby et al. 2012), however, the rank of subspecies is often applied to taxa that are clearly closely related, differentiated by at least one morphological trait, but are largely or entirely allopatric (e.g. Stuessy et al. 2014, Braby et al. 2012), whereas ranks of variety or form are used for taxa of closer morphological similarity (e.g. differing by a single trait) or sympatric occurrence respectively. Accordingly, A 'Typo' is described here as a new subspecies differing from typical *A. boormanii* principally in its broader phyllodes, more pronounced indentation of the phyllode margin at the gland, and a rounded phyllode apex (ignoring the mucro). Two A. 'Typo' specimens grouped with typical *A. boormanii* in the dendrogram (Figure 2). Closer scrutiny of these two specimens revealed that they had less rounded phyllode apices and less pronouncedly indented marginal glands than were typical for A. 'Typo' and were scored accordingly, leading to their grouping with *A. boormanii*. They were otherwise similar to other A. 'Typo' specimens in phyllode characters. In ordination space (Figure 3), the same two specimens (indicated with asterisks in Figure 3) appear to overlap those of typical *A. boormanii* in two of the orientations (axes 1 vs 2, 1 vs 3; Figs 3a and 3b respectively), but rotation of this array more clearly groups these with the remainder of the A. 'Typo' specimens (Figure 3c).

Based on the dendrogram of phyllode characters, A. 'Gapsted' specimens grouped more closely with specimens of typical *A. boormanii* than with A. 'Typo' although the Gapsted population has more variable phyllode length and width than is typical for subsp. *boormanii*. Geographically, A. 'Gapsted' is much nearer A. 'Typo' than typical *A. boormanii* and might have been expected to resemble it morphologically. Although not scored in this study, it was also noted from field observations that the pattern of the branching varied within the Gapsted population, with certain plants featuring erect branches and others with a widely sprawling form not apparent in typical *A. boormanii* or A. 'Typo'. All plants within the A. 'Gapsted' population appear to be derived from root suckers. *Acacia* 'Gapsted' has not been observed to produce seed through at least 20 years of observation of the population (N.A.F. Gibb, pers. comm.) and, like *A. infecunda*, is likely to be a relictual population persisting solely via vegetative reproduction (Molyneux & Forrester 2008).

Acacia infecunda

Acacia infecunda was distinguished from *A. boormanii* by its inability to set seed, dwarfed features (habit, phyllode length, capitulum size) and isolation from *A. boormanii* populations (Molyneux and Forrester 2008). However, our measurements indicate that *A. infecunda* cannot be distinguished morphologically from *Acacia boormanii*. The ordination of morphometric data in our study found specimens of the species were nested within *A. boormanii* in ordination space. Therefore, based on our data, the distinction of *A. infecunda* relies largely on its apparently inability to set seed and extensive root-suckering habit, which are traits shared with the Gapsted population of *A. boormanii*. In cultivation, *A. boormanii* often suckers from roots at least up to a few metres from the 'mother' plant, so that trait, while expressed to an extreme in *A. infecunda* and the Gapsted population, exists to some extent within the species. Interestingly, A. 'Typo' is not known to spread by root suckers (pers. obs.). Other species of *Acacia* are known to develop populations that exhibit, to varying extents, dwarf or prostrate habit, root-suckers, infertile flowers etc. (e.g. *A. ocinocaea* Lindl., *A. boileyan* F.Muell., *A. deolbato* Link, *A. howittii* F.Muell., *A. iteophyllo* F.Muell.). However, none has been considered worthy of formal taxonomic recognition. It could be that *A. infecunda* represents one such population. O'Brien et al. (2014) found non-fruiting populations of *A. corneorum* Maiden to have lower genetic diversity than fruiting populations and inferred a long period of isolation. *Acacia infecunda* possibly represents a similarly long-isolated population of *A. boormanii*. Our study employed the only 2 herbarium specimens available to us of *A. infecunda* so we suggest further analysis, using a wider range of specimens, is warranted to verify its taxonomic integrity.

Non-morphological techniques (e.g. chemical, molecular) may shed further light on the relationships between the Gapsted population, *A. infecunda* and the remaining populations of *A. boormanii*

Taxonomy

***Acacia boormanii* Maiden, J. & Proc. Roy. Soc. New South Wales 49(3): 489 (1916).**

Type: Macnally Ranges [= Macanally Mtn], N.S.W., 25.ix.1913, J.L.Boormon s.n. (holo: NSW166396; probable

iso: BM, C, CANB, K, MEL (all '27.ix.1913') and NSW166408 ('ix.1913')).

Acacia hunteriana N.A.Wakef., *Victorian Nat.* 72: 92 (1956). T: Victoria: banks of Snowy River, near Deddick, 8.ix.1955, N.A. Wakefield 4810 (holo: MEL 1508588; iso: BRI, CANB).

Foliose shrub to 4 m high; branchlets glabrous or sparsely and minutely hirsute, often pruinose at extremities. *Phyllodes* spreading to erect or deflexed, narrowly linear to narrowly oblanceolate, (1-)3-6(-7.5) cm long and 1.5-2(-4.6) mm wide, straight or slightly falcate, not rigid, glabrous except for adaxial side of pulvinus which is often sparsely hairy, green to grey-green or pruinose, at least when young, narrowed at base, normally obliquely and eccentrically mucronate; midrib and lateral veins indistinct; *gland* not prominent, 2-14 mm above pulvinus. *Racemes* with rachis (7-)10-20(-33) mm long, slender, straight to flexuose, glabrous to subglabrous, often pruinose; *peduncles* 2-4 mm long, slender, glabrous to subglabrous; heads prolific, globular, 3-5 mm diam., 5-11-flowered, yellow. *Flowers* 5-merous; sepals united. *Pods* linear, 3-9 cm long, 4-6

mm wide, firmly chartaceous, dehiscent unilaterally, glabrous; *seeds* mostly 3-11 per pod, longitudinal, oblong-elliptic, 3.8-5.6 mm long, 2-3 mm wide, somewhat shiny, black, aril half to two-thirds the length of seed. *Flowers* Aug.-Oct.

Acacia boormanii subsp. *boormanii*

Shrubs commonly suckering from roots. *Phyllodes* often deflexed below inflorescence, linear, 1.5-2(-2.5) mm wide, margin not or very indistinctly indented around gland; apex acute (rarely rounded), not pruinose, or sparsely to moderately pruinose.

Occurs disjunctly from Macanally Mtn, near Cooma New South Wales to south of Thredbo Village, New South Wales, and south to Buchan, Victoria, with an outlying occurrence at Gapsted in north-eastern Victoria.

Acacia boormanii subsp. *gibba* K.J.Tucker subsp. nov.

Acacia boormanii var. *Mount Typo* (F.E. Bienvenu 11) Vic. Herbarium sensu CHAH (2006); Maslin (2013).

Type: VICTORIA. Mt Typo, just south of saddle crossed by vehicular track, 0.8 km N of summit, 22 km SE from



Figure 5. Flowering specimen of *Acacia boormanii* subsp. *gibba*. (photo N.A.F. Gibb, Sept. 2013)

Whitfield, 1.ix.2013, *K.J. Walsh s.n.* (holo: MEL 2385038A; iso: AD, CANB, NSW).

Shrubs, not root-suckering. *Phyllodes* mostly acutely inclined to stem, those immediately below the inflorescence sometimes spreading to ca. 90 degrees, oblong to narrowly elliptic or narrowly oblanceolate, straight to slightly falcate, 2.5–5 mm wide; margin



Figure 6. Fruiting specimen of *Acacia boormanii* subsp. *gibba*. (photo K.J. Tucker, Dec. 2013)

commonly distinctly indented around the gland; apex usually asymmetrically rounded, typically distinctly pruinose. (Figures 5 & 6)

Specimens examined: Eastern slopes of Mt Typo, 12.ii.1976, *P.D. Cheal s.n.* (MEL); Mt Typo to Mt Warwick, iv.1976, *A. Gibb s.n.* & *F. Bienvenu s.n.* (MEL); Approx. 25 km SSE of Whitfield. Saddle south of Mt Typo summit, 19.ix.1976, *A. Gibb s.n.* (MEL); Approx. 12 km SE of Whitfield, 19.ix.1976 & 20.ii.1977, *A. Gibb s.n.* (MEL); c. 1.2 km along Upper Rose River Road, 20.viii.1977, *F. Bienvenu s.n.*, (CBG, MEL, NSW) and *E.M. Canning 4277* (AD, CBG, MEL, NSW); 2.4 km N of Bennies along Upper Rose River Rd, 20.viii.1977, *F. Bienvenu s.n.* (CBG, MEL, NSW); 4.8 km N of Bennies along Upper Rose River Rd, 20.viii.1977, *F. Bienvenu s.n.* (CBG, MEL, NSW); Mt Typo, knoll to the N end, 17.xii.2013, *K.J. Tucker 1* (AD, CANB, MEL, NSW).

Distribution: *Acacia boormanii* subsp. *gibba* is confined to Mt Typo and environs near Rose River, north-east Victoria.

Habitat: The plant community in which the main population of *A. boormanii* subsp. *gibba* occurs is mainly a shrubland with the wattle often dominant. Other common co-occurring species include *Dodonaea viscosa* subsp. *cuneata* (Sm.) J.G.West, *Calytrix tetragona* Labill., *Cassinia longifolia* R.Br., *Hibbertia obtusifolia* DC., *Stypantra glauca* R.Br., *Isotoma axillaris* Lindl., *Cheilanthes sieberi* Kunze and occasional eucalypts, e.g. *E. radiata* DC., and *E. rubida* H.Deane & Maiden. Soils are skeletal, overlying the Carboniferous conglomerate of which the prominent Mt Typo range is composed (Figure 7). Mean annual rainfall is ca. 1050 mm (although runoff is high and effective rainfall probably considerably less). The subspecies occurs over an altitude range of ca. 470–750 m. Small outlying subpopulations c. 1 km north and up to c. 5 km south-east of Mt Typo occur in open forest dominated by *Eucalyptus radiata* and *E. rubida*.

Conservation status: Given the very restricted areas of extent of occurrence and area of occupancy (sensu IUCN 2001), the risk category for *A. boormanii* subsp. *gibba* is calculated as CR (Critically Endangered) due to the vulnerability of the habitat to degradation primarily through projected increased fire frequency with climate change, jeopardising recruitment of the population in the medium- to long-term.

Etymology: The epithet derives from the latin *gibbus* - a hump, alluding to the prominently raised profile of Mt Typo, but also making reference to N.A.F.(Alan) Gibb, a local naturalist and *Acacia* expert who first made



Figure 7. Mt Typo with *Acacia boormanii* subsp. *gibba* dominant on upper slopes (the distinctive summit of Mt Cobbler left of Mt Typo). (photo K.J. Tucker, Dec. 2013)

collections of the subspecies in 1976. It is here modified to the feminine to agree with the gender of the genus and is treated as a substantive.

Notes: The new subspecies is separated from subsp. *boormanii* in having broader phyllodes (mean 2.8–4.6 mm wide for subsp. *gibba* vs 1.5–2.4 mm wide for subsp. *boormanii*) that have a rounded rather than acute apex (ignoring the short mucro which is present in both subspecies) and typically have the margin indented (not straight) at the gland. A number of other characters, while not utterly diagnostic are at least indicative and contribute further to the separation of the two subspecies: the stems of subsp. *gibba* are invariably glabrous and pruinose while this is not always the case in subsp. *boormanii*; the phyllodes of subsp. *gibba* are typically highly pruinose, especially when young while those of subsp. *boormanii* are rarely or indistinctly pruinose; the phyllodes immediately subtending the inflorescences are very often conspicuously reflexed in subsp. *boormanii*, but only rarely so in subsp. *gibba*; and subsp. *boormanii* commonly shoots from root-suckers,

but this trait has not been observed in subsp. *gibba*.

While the distribution of subsp. *gibba* is believed to be concentrated on and near Mt Typo in north-east Victoria, three collections from the Bowen Range, East Gippsland (*Beaglehole* 37163, MEL 536856; *Cameron s.n.* MEL 1555594; *Cheal s.n.* MEL 1563149), some 185 km ESE of Mt Typo but under 20 km E from the nearest occurrence of *A. boormanii* subsp. *boormanii*, differed from other specimens retrieved as subsp. *boormanii* by their broader-than-typical phyllodes (means of 3.7 mm, 2.9 mm, 2.7 mm wide respectively). While on the basis of this character alone, these might be expected to group with subsp. *gibba*, most of the other characters of these specimens were not consistent with that taxon – e.g. presence of hairs on some branchlets, lack of wax on two specimens, and the phyllodes subtending inflorescences spreading to reflexed. There is no direct evidence to suggest these specimens were or were not root-suckering, but on one sheet (*Cameron s.n.*) it is noted that ‘most plants sterile and none bearing fruit’, which is a characteristic often associated with

root-suckering populations (e.g. at Gapsted, and in the population representing *A. infecunda*). In the absence of a more complete suite of specimens from this relatively remote area, these specimens are provisionally retained in subsp. *boormanii*.

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